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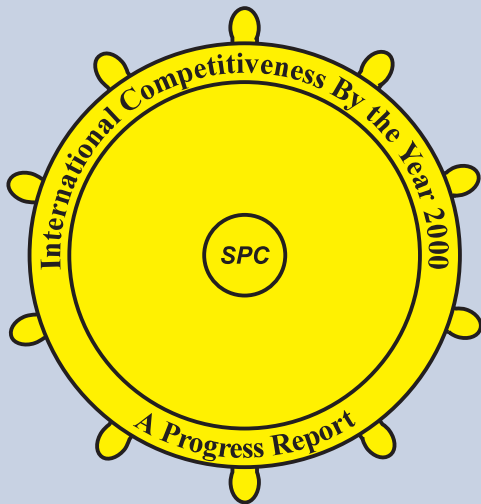
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STEP Implementation For U.S. Shipbuilders - MariSTEP Progress Report

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ABSTRACT

MariSTEP is a DARPA/MARITECH sponsored cooperative agreement among several shipyards, CAD vendors, and a major university to prototype the exchange of shipbuilding data between diverse shipyard environments using STEP, an International Standard for the Exchange of Product Model Data. The goal of the three year MariSTEP effort is to implement transfers using the STEP Shipbuilding Application Protocols to exchange product model data among the participating shipyards. The project is in its first year, and this paper reports on the progress made thus far, along with outlining the overall project plans.

NOMENCLATURE

AP	Application Protocol
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CIM	Computer Integrated Manufacturing
DARPA	Defense Advanced Research Projects Agency
DXF	Data Exchange Format
EMSA	European consortium to develop STEP Standards for Shipbuilding; Active from 1996-1999
ERAM	Engine Room Arrangement Model
IGES	Initial Graphics Exchange Specification
ISO	International Organization for Standardization
MariSTEP	DARPA funded project for Development of STEP Ship Model Database and Translators for Data Exchange Between Shipyards
MARITIME	European consortium to develop STEP Standards for Shipbuilding; Active from 1992-1995
NEUTRABAS	European consortium to develop STEP Standards for Shipbuilding; Active from 1988-1991
NIDDESC	Navy / Industry Digital Data Exchange Standards Committee
PMDB	Product Model Database
SQL	Structured Query Language
STEP	Standard for the Exchange of Product Model Data

INTRODUCTION

The MariSTEP program is a unique implementation

effort with the team membership representing a diverse combination of shipyards and CAD vendors. Using STEP (the Standard for the Exchange of Product Model Data), the team aims at the exchange of shipbuilding data among the five differing environments represented within the membership. Product model data exchange is a key element in allowing the use of computer and information technologies to competitive advantage.

SHIPBUILDING AND THE PRODUCT MODEL

The use of computers and information technology in shipbuilding, as well as other industries, has proliferated as the cost of hardware and software has come down. Monolithic mainframe systems have either been replaced or augmented by smaller workstations and personal computers, and they are used for more applications than just developing paper drawings and printing payroll checks.

There has emerged from the implementation of computer integrated manufacturing (CIM) the concept of a product model. As computers, automation, and information technology became more common in engineering, business, and manufacturing, the possibility of a monolithic database to provide integration of these "islands of automation" became the goal of those hoping to enhance their competitive position. This has evolved into the *product model*.

The product model is defined as the complete set of information that describes a particular object over its entire life cycle. Restated, the product model is the body of information or database that represents a product's design, engineering, manufacturing, use, and disposal.

As the types of data elements in this model become more complex, the problem of storing, retrieving, and using this information for all of the enterprise applications becomes a

significant issue. When the enterprise had a single technology vendor and centralized control of information, integration was less of a problem. The formats for exchange of information between applications in a vertically integrated business was controlled by the enterprise and the information systems department of that business. Many of the formats for information were proprietary or special purpose.

Nevertheless, technology has moved forward with higher performance for less cost. This has allowed distribution of information throughout a business. Manufacturing has its own information resources, as does engineering and the business offices. Further, business practices have changed resulting in more out-sourcing of manufacturing and subcontracting of services. Each of these businesses has its own information systems and resources.

In a sense, all of this information makes up the product model. Business practices revolve around the exchange of information as much as exchanges of physical materials. There is seldom centralized control of technology in an enterprise information systems department. Consequently, there is a need for standardization of information formats to make the exchange of product model data efficient and practical in shipbuilding. The MariSTEP project was conceived to address, and solve, this problem.

THE MariSTEP PROJECT

This project was developed in response to an invitation from the Defense Advanced Research Projects Agency (DARPA, formerly ARPA) to submit a full technical and cost proposal based on the project abstract entitled "Development of STEP Ship Model Database and Translators for Data Exchange Between U.S. Shipyards." In negotiations with DARPA, the team membership was increased to include additional shipyards and vendor participants.

In the interest of the U.S. shipbuilding industry and the U.S. Navy, a consortium of qualified parties was formed to respond to this invitation. This consortium is being led by Intergraph Federal Systems. Other members include :

- Avondale Industries

- Computervision Corporation
- Electric Boat Corporation
- Ingalls Shipbuilding (a Division of Litton Industries)
- Kockums Computer Systems
- Newport News Shipbuilding, and
- the University of Michigan.

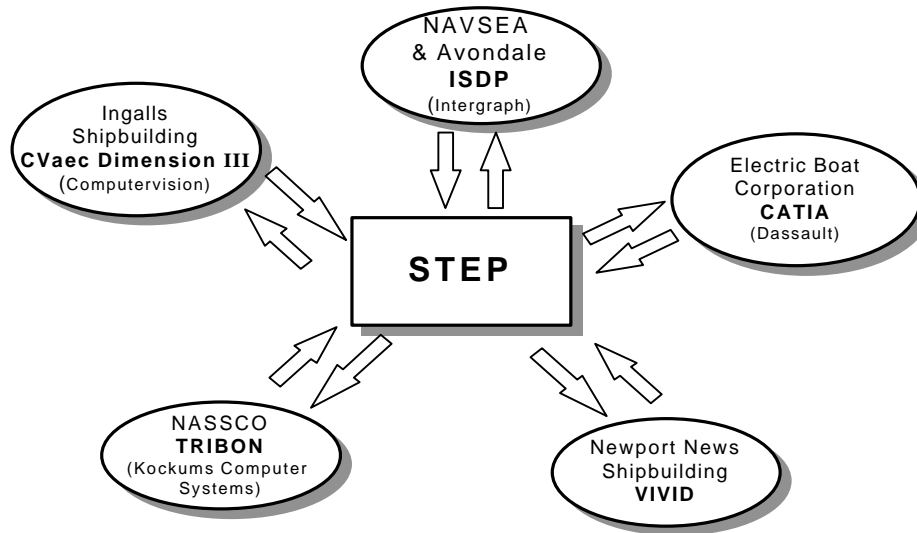
The relationship of the shipbuilders and their CAD vendors is demonstrated in Figure 1. Advanced Management Catalyst serves as a facilitator at several meetings during the project.

The objectives of this project are to implement a neutral file transfer capability between the product models at the U.S. shipyards, and to develop a United States marine industry prototype Product Model Database (PMDb) which will facilitate the implementation of translators and product model data architectures by U.S. shipyards and CAD system developers.

Background

The benefits of digital data exchange have been recognized since the advent of computer aided design and manufacturing systems in shipyards. Standards such as the Initial Graphics Exchange Standard (IGES) have been developed to transfer data between existing CAD systems. The advantages of digital data transfer between design agent and shipbuilder were clearly demonstrated on Navy programs such as the Arleigh Burke Class destroyer and the SEAWOLF submarine. However, there is no system used in ship production to transfer a complete set of product model data which would be required to provide a full description of a modern ship.

STEP is an International Standard (ISO 10303) designed to meet the digital data transfer requirements of computer systems in many industries today and for the foreseeable future. Unfortunately, the initial version of this specification (issued in 1994) does not address the needs of the shipbuilding industry, even though there have been concerted efforts since 1986 to incorporate



MariSTEP Shipbuilding Data Exchange

Figure 1 - Typical Data Exchange Paths for Ship Product Model Data

shipbuilding requirements into the development of the standard

NIDDESC (Navy / Industry Digital Data Exchange Standards Committee) was a cooperative effort, begun in 1986, among U.S. shipbuilders and the Navy, whose goal was to have the requirements of the shipbuilding industry reflected in STEP. NIDDESC developed a suite of six Application Protocols (APs) which incorporated the requirements of the shipbuilding industry in STEP format, and delivered these to the International Organization for Standardization (ISO) in 1993.

While NIDDESC was developing Application Protocols in the United States, several efforts were underway in Europe to outline the requirements of shipbuilding for STEP as seen by the European shipyards and regulatory agencies. European initiatives such as NEUTRABAS, MARITIME, and now EMSA have contributed to the STEP development efforts, but have provided a different view of the problem than that addressed by the NIDDESC APs. These many efforts have led to five shipbuilding Application Protocols now being accepted as work items for STEP by ISO TC184/SC4/WG3. These APs represent a combination of the NIDDESC efforts and the various European initiatives.

The MariSTEP program will be the first large scale implementation of the shipbuilding Application Protocols, and its efforts should assist in improving these documents, and should help accelerate their adoption as International Standards.

MariSTEP Vision

At the outset of the MariSTEP project, the team formulated and verbalized a vision for the future, based on the successful outcomes of this project. The premise was that the vision should be a representation of the way the shipbuilding community would be conducting business in the year 2001, as a

result of these outcomes.

This is an ambitious five-year projection. It proposes daily use of many processes and capabilities that do not presently exist, or exist only as a rudimentary beginning. It envisions the acceptance of a set of world-wide standards as a U.S. national standard, adhered to by vendors, suppliers, and shipbuilders alike, with a standard mechanism for sharing electronic data to a degree that has never before been possible.

Electronic commerce is the way of the future in many businesses, as in shipbuilding. The MariSTEP project is intended to be the catalyst for this kind of progress and will serve to prototype the means to that end.

The MariSTEP Vision expresses the goals of the project to enable the shipbuilding community to exchange product model data between different shipbuilding information systems without loss of intelligence - easily, quickly, cost-effectively and reliably.

It further specifies that this will be accomplished through the use of a single internationally accepted standard (STEP), enabling shipbuilders, design-agents, owners, operators, regulatory bodies, classification societies, sub-contractors, government agencies and vendors to exchange ship product model data.

Data exchange of pertinent information both within organizations and across organizations supports activities involved in the life cycle of a ship:

- conceptualization
- design
- construction
- testing & evaluation
- training
- repair

- maintenance
- operation
- disposal

Since most of the major U.S. shipyards and their CAD/CAM vendors are represented in the consortium, the MariSTEP project is in a position to provide these enabling technologies to the shipbuilding community, allowing processes to be re-engineered to take full advantage of product model data transfer capabilities. Effective use of these capabilities throughout all levels of the enterprise will allow production and maintenance of quality ships cost-effectively.

The STEP data exchange capabilities will enable the U.S. shipbuilding industry to be a viable competitor in world markets. The prototypes resulting from the MariSTEP project should become the foundation for the shipbuilding data exchange products which will be commercially available in the years ahead.

ACTIVITY AND AP SELECTION

A primary task of the first phase of the MariSTEP project was to determine the scope of product model data transfer to be covered by the implementation prototype. This scoping activity included selection of the primary activities, development of exchange scenarios, and a detailed evaluation of application protocols.

The activities reviewed included those of ship design, construction, and operations life-cycle that should be supported by a prototype product model transfer capability. The exchange scenarios were those between the various organizations involved in the design and construction of a ship which would likely require transfer of product model data. A detailed evaluation was done of the ISO and NIDDESC shipbuilding application protocols to determine which of the standards would provide the most useful product model information to support transfers between the shipyards for the chosen life-cycle activities, and which of the standards were sufficiently complete to allow implementation within the duration of the project.

Activity Selection

During the development of the NIDDESC application protocols, Application Activity Models were created to document the life cycle phases within the ship design and construction process and to illustrate the types of information created during each life-cycle phase which is passed to the succeeding phases. An Activity Model was created for each design discipline by experts from the various shipyards and design agents working on the NIDDESC application protocol project. The Activity Models were documented using the IDEF0 activity modeling methodology.

Figure 2 is a sample Activity Model which was first developed for the NIDDESC Ship Structure Application Protocol. The boxes labeled Feasibility Design, Functional Design, Detail Design, and Production Engineering are the primary life-cycle activities during which product model data is created by an organization,. It is the data from these activities which may need to be transferred to another organization or to another group within the same organization. The outputs from these activity boxes illustrate the types of information created during these primary activities. The information types are the requirements which drove the development of the data models documented in the application protocols. Similar activity models were created as a scoping mechanism for each of the ISO shipbuilding application protocols. The ISO Activity Models were created by the European Maritime Project and deal less with ship design and production and more with the ship design approval process by a classification body, and with ship operations and inspections.

The MariSTEP team evaluated both the NIDDESC and ISO Activity Models to determine which activities and information types should be supported to provide the most benefit to the U.S. shipyards for exchanges between business partners during a particular activity and for “down-stream” transfer to organizations involved in later stages. The primary activities selected for implementation included data developed during the Functional Design, Detail Design, and Production Engineering phases.

EXCHANGE SCENARIOS

To further focus the intended scope of the prototype, the team evaluated various potential exchange scenarios for the collaborative design and construction process that exists in the shipbuilding industry. Historically one organization would be responsible for an entire design or construction phase. However, multifaceted teaming arrangements are employed in shipyards during design and construction to reduce the ‘time to market’ for a new ship, and to more effectively use available design and manufacturing talent in a shrinking industry. The recent bids submitted on the LPD17 proposal demonstrate this new type of teaming arrangement. Figure 3 illustrates various product model exchanges that can be expected within the industry. The activities within the shaded triangle involve those scenarios the team decided to address for the initial prototype. These are exchanges of product model data between a design agent (either independent or within a shipyard organization) and a design subcontractor (also either independent or another shipyard) during either the Functional or Detailed Design phases, between a design agent and a shipbuilder for construction of the design from information produced in the Detailed Design and Production Engineering phases, and between two shipbuilders who might share construction of a single ship or a class of like ships.

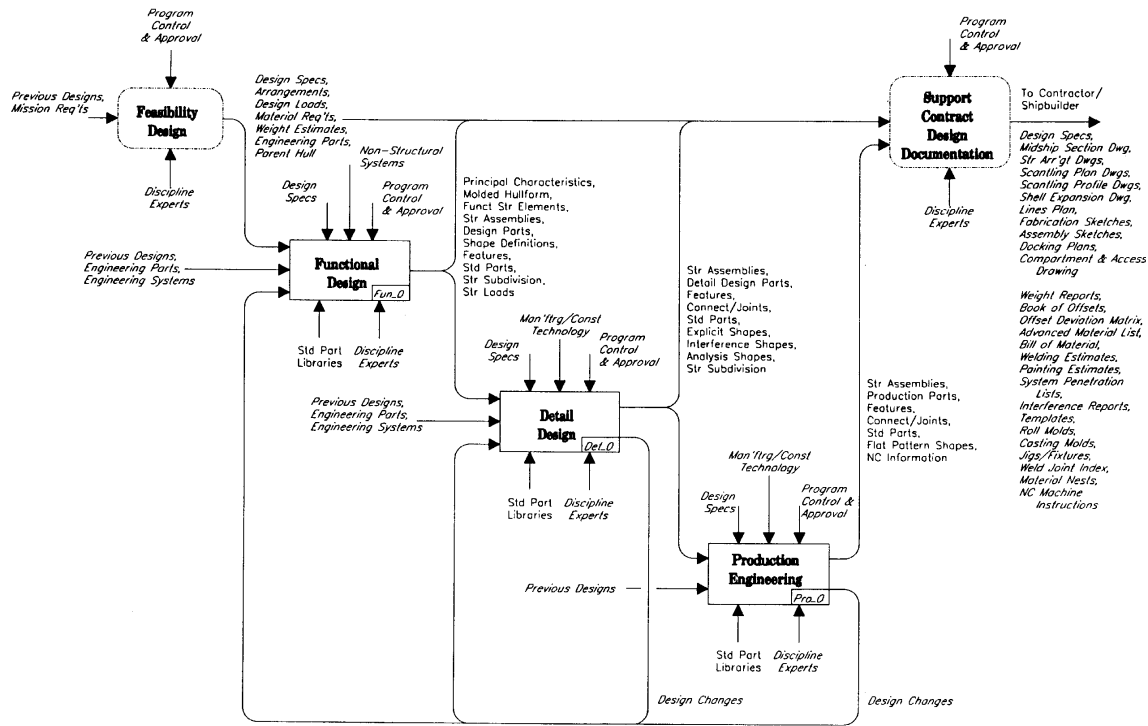


Fig. 1 Ship Structure AP scope

Figure 2 - Ship Structure Activity Model

Evaluating the Application Activity Models and evaluating and choosing industry exchange scenarios helped to focus the team on the scope of product data that would need to be supported by the prototype translators. It also aided in the evaluation of the available information models for determination of the quality and completeness of the existing models and areas that would need to be developed during the remainder of the first phase of the project to produce an implementable schema and would be useful to the participating organizations upon completion of the project.

As part of the requirements definition effort undertaken in the first phase of the MariSTEP Project, a number of exchange scenarios were identified that promised significant benefits. These

different data exchange scenarios were then used as guidance as candidate schema modifications were considered, and as the MariSTEP Project Testing Plan was prepared. The translator technology was developed to broadly benefit the ship design and shipbuilding community. *The project scope was biased towards usefulness in transferring information in the design phases where the greatest benefits were, and where it was seen that the greatest volume of product model information was developed and exchanged.* That scope was determined to wholly include detailed design information and much of the information developed during production design, functional design, and preliminary design.

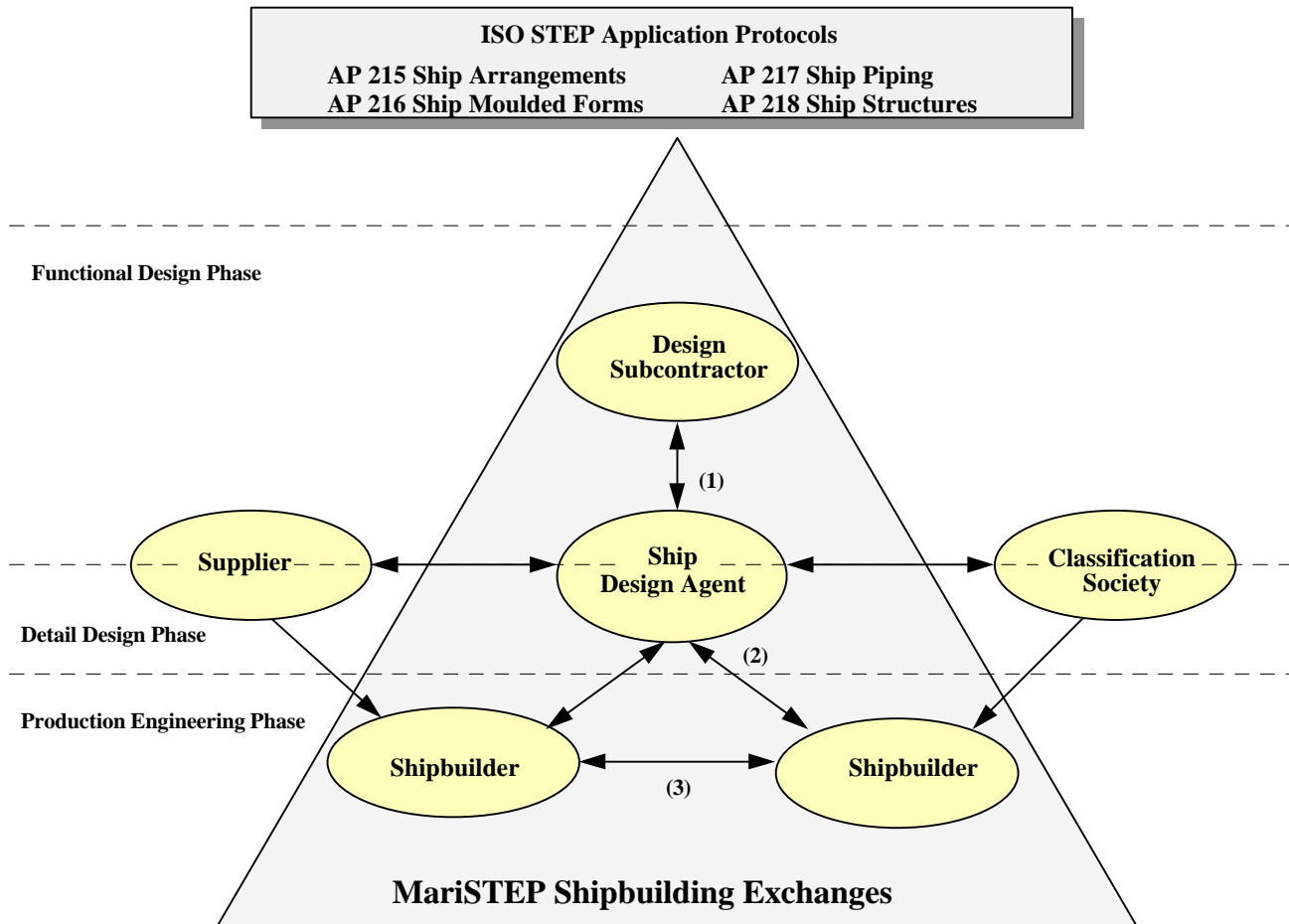


Figure 3 - Typical Data Exchange Paths for Ship Product Model Data

Exchanges were also characterized by the type of information that would typically be transferred. Information content varies with the particular stage of the process as with the type of organization involved. The matrix in Table I shows some of the volume characteristics of the information content that these different exchange scenarios typify.

Design Agent - Shipyard Scenario

The most traditional exchange path for U.S. shipbuilders is the exchange of information between the design organization and the shipyard. This applies in the same way if the design organization is external, as in the case of a design agent, or if referring to the internal design organization of the shipbuilder. The largest volume of information in this scenario is detailed design information describing the hull structure and the arrangement and details of all machinery and outfitting systems included. Information is exchanged during the early stage design

for reasons such as the shipyard's build strategy development and other planning purposes, but the volume increases greatly during the detailed design stage as work instructions are developed from the detailed design. This is also the stage of design where the most concurrency is necessary.

There are a number of benefits to the ship design process in having technology that allows the exchange of intelligent ship product models in this scenario. STEP, as a neutral format for product model exchange, enables organizations to work in different design environments. External design agents maintain multiple CAD systems so that they may service the needs of their different customers that usually do not have the same systems. This is also sometimes a reality when the design organization is internal to the shipyard. This is not the most productive or efficient way to operate when training and other infrastructure requirements are considered.

KEY

L = Large Volume of Data to be Transferred
M = Moderate Volume of Data to be Transferred
S = Small Volume of Data to be Transferred

TO FROM	DESIGN AGENT	SUB CONTRACTOR	SUPPLIER	REGULATORY AGENCY	SHIP- BUILDER
DESIGN AGENT	-	L	M	S	L
SUB CONTRACTOR	L	-	S	S	M
SUPPLIER	L	M	-	S	L
REGULATORY AGENCY	S	S	S	-	S
SHIPBUILDER	L	L	S	S	L

Table I - Data Exchange Information Content

Shipyard - Shipyard

Another exchange scenario that has been seen in recent U.S. shipbuilding projects is multiple yard building programs. There may be some differences in the mechanics of this type of arrangement. In the lead-follow yard concept, detail design is accomplished in the lead yard and then transferred to the follow yard during the detailed design phase. Another variation is where the detailed design function is shared by some division of the ship either by physical boundaries (fore-aft, etc.) or by division of systems where each shipyard develops design data which must be passed to the other.

Few U.S. shipyards use the same CAD systems. In recent projects such as the Arleigh Burke Class destroyer and the SEAWOLF submarine, there were significantly large costs associated with special means employed to enable this type of digital information exchange. In each of these projects, very different methods were developed and employed. The exchange products developed for these organizations would be only partially useful in another project because they were tailored to the organizations and systems involved at the time. The STEP standard presents a technology for multiple design organizations to pass such ship product model information in a way that would be understood by an equivalent shipbuilding CAD system without customized translation software.

Other Exchange Scenarios

Although the two exchange scenarios discussed above have the biggest payback, there are numerous other transfers possible in the shipbuilding process which can also benefit from the availability of a product model exchange capability. Among these are :

- Exchanging purchased component data from material suppliers,
- Subcontracting portions of a ship design project,
- Design collaboration between partners;
- The "Virtual Shipyard" ,
- Purchase or licensing of designs from other shipyards or

design agents,

- Internal exchanges between dissimilar internal systems, and
- Design Organization - Regulatory Body

TEST DATA SELECTION

Whereas Task I of the MariSTEP project revolved around determining program scope, Task II involves development of a Product Model Database (PMDB).

The Product Model Database defines ships' systems and assemblies of the building blocks selected for the prototype implementation in STEP format. The primary purpose of the database is to define STEP data which can be used to evaluate translators. The development of the database satisfies a critical requirement to evaluate the application protocols using actual data required for design and construction. Evaluation of the PMDB will also determine the ability of the information to represent ship design and construction data.

Description of the Test Data

The first step in PMDB development is to determine the information to be included in the database. The initial definition of the PMDB is very general with additional detail provided as it becomes available. The goal is to define all of the types of data to satisfy the classes defined by MariSTEP, while minimizing the amount of data. For example, the product model may contain pipes, components, equipment, etc. to define a portion of a system, but not all of the systems required for a complete engine room design will be represented. The objective of the test cases is to exercise a broad range of information while minimizing the amount of data. In order for the data to be acceptable to the participants and non-proprietary in nature, it has been culled from a Navy ship design project, the Engine Room Arrangement Model (ERAM).

Engine Room Arrangement Model Data

The ERAM model is a slow speed diesel engine room

designed to be commercially viable while satisfying the requirements of the U.S. Navy Sealift Program. The Intergraph ISDP suite of ship design software is being used to synthesize the MariSTEP Product Model Database. The ERAM product model data consists of hullform, compartmentation, decks and bulkheads, structure, outfit and furnishings, piping, and HVAC. The hullform is defined for the whole ship. Theoretical surfaces are only defined for the decks, bulkheads, and compartments in the engine room and stack. Plates and stiffeners are placed on decks and major bulkheads. At this stage in the ERAM program, end treatment and cutouts have not been defined. All major equipment has been placed, however, a minimum set of attributes has been defined. Distributed systems are limited to pipelines larger than 50mm (2in) for the major piping systems. Ventilation is modeled in the stack and includes engine and generator exhaust. The model also defines pipe lanes, cableway lanes, and reserved areas for ventilation.

Early Stage Data Exchange

The first version of the Product Model Database in STEP format will be developed directly from the ERAM CAD data. The theoretical surfaces and equipment geometries are provided to the other participants using existing technology such as IGES and DXF. The attribute data is provided as a combination of text files and SQL statements. This will allow each of the participants to begin to develop their native product model databases without having developed STEP translators. Each participant will be responsible for developing specific types of data and translating it to the Product Model Database. Ultimately, a

reduced set of test data will be defined as a result of the combined effort.

MariSTEP TIMELINE

The MariSTEP program is a three year effort that was officially kicked off in July, 1996 and is targeted for completion in June, 1999. The program is divided into four tasks, with Task I representing the initial stage of the program and Tasks II, III, and IV following the completion of Task I in April of 1997 and running concurrently through the remainder of the program. The relationship of these tasks is shown in Figure 4.

The initial stage of the program, Task I, focused on defining the scope of the entire implementation effort, beginning with a study of the existing ISO and NIDDESC APs. At the end of November, 1996, the APs for implementation were selected and all shipyard environments had begun to evaluate their own data sets as compared to those requested in the shipbuilding APs. In addition, by the end of December, 1996, the shipbuilding processes to be supported in the exchange were identified. A challenge of this effort was the selection of a subset of data that was rich enough to be meaningful but small enough to be achievable in this limited timeframe.

At the end of January, 1997, the team had identified all aspects of the data exchange and was beginning to define the schema to be used in the implementation phases. The schema(s) must be completed by the end of Task I in order to support the implementation phases of Tasks II and III.

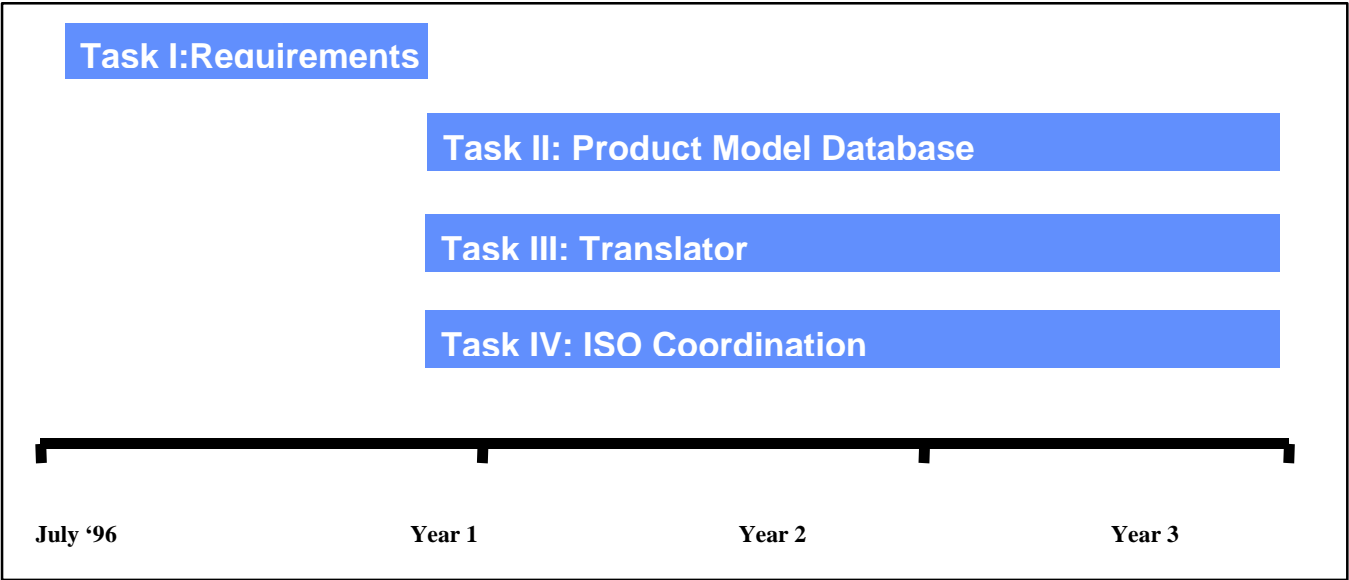


Figure 4 - MariSTEP Timeline

Beginning in May, 1997, Tasks II and III are dedicated to implementation of the data exchange defined in Task I, aiming at

- 1) creation of a Product Model Database (Task II) which will be used for testing purposes and
- 2) actual translator implementations for each of the five shipbuilding environments in support of data exchange

(Task III).

Also beginning in May '97 is a task to track the ISO APs. This effort will be critical to the effort since a goal will be to assure that any deviations from ISO are factored back into the ISO Draft APs. All issues and deviations from the Draft APs will be documented and submitted to the ISO Committee(s) throughout the program in order to influence the evolving ISO Standards

SUMMARY

MariSTEP is a DARPA / MARITECH sponsored cooperative agreement including the U.S. Navy, major U.S. shipyards, their CAD vendors, and research centers.

It is developing a prototype of a ship Product Model Database allowing ship production data to be exchanged between cooperating yards and the Navy with an integration never before achieved.

MariSTEP is developing processes that enable concurrent design and production among cooperating U.S. yards working on the same ship.

The project is utilizing the ISO STEP Product Data Exchange Standard (ISO-10303) to ensure that U.S. yards can access ship production data from any client in the world, enabling U.S. yards to bid, work, and win in the global shipbuilding arena.

Thus, the MariSTEP program represents a unique opportunity for a diverse group of organizations to work together toward a common goal that will benefit the U.S. shipbuilding industry and further the progress of data standards throughout the world. The project team recognizes the importance of its endeavor and is committed to its successful completion.

For more details about the MariSTEP project and its members, you can visit the web site at :

www.intergraph.com/federal/STEP

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